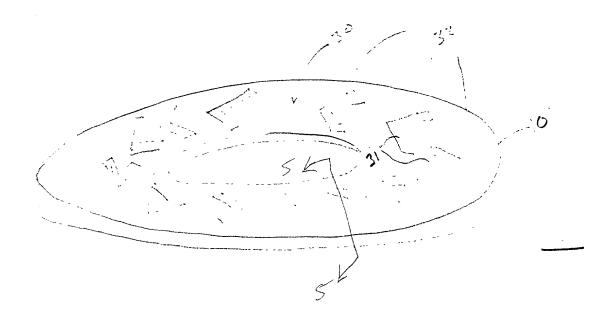
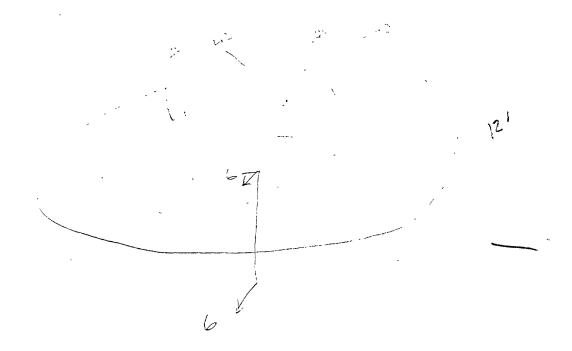
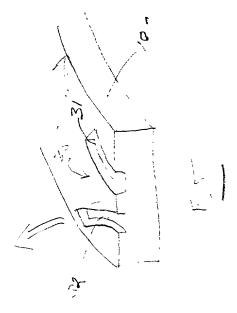
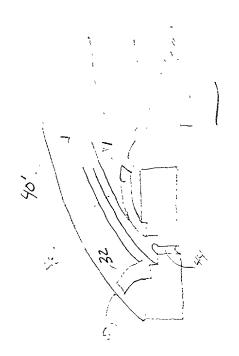


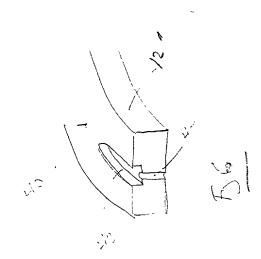
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manufacturing reasons.

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Wellesley, MA 02181-4078			J .
Title: Retractable adaptive	divert-groove film-riding face seal		
Inventor(s): Xiaoqing Zhen	g ,//		
explained later, Normally, t	he deep feeding groove is not segmented as st	nown in Figure 2 for	

Preferably, seal face patterns shown in Figure 1 or 2 are on the face of stator ring 200. But they can be a combination of the imprints on rotor and stator faces 200,201. For example, the feeding groove 104 and hole 105 can be on the stator ring 100 while the groove 101,106 and dam sections 102,107 are on rotor ring 201. In such case, the two hydrodynamic sections (groove section) 101,106 can extend and meet at the center. Please note that the number of pairs of groove and land can be different for inner and outer seal sections 109,110 in the non-segmented design. However for ease of plotting, same numbers of groove-land pairs are used in all the figures in this disclosure. In addition, the pumping grooves 101,106 are normally-200-900 micro inches in depth; they are shown exaggerated in some plots to better demonstrate the seal configurations.

Outer Section Inner Section Outer Section Land. 108 Outer Section 109 1/008 Dam. 107 01 Outer Section Groove, 106 Restricted Feeding Feeding, Inner section Inner section Inner section Grooxé. 104 hole/105 Dan 102 Groøye. 101 Land 103

Figure 1. Typical seal face layout for segmented feeding grooves

As mentioned before, a very interesting implementation of the above described idea is to put divert grooves 101,106 on the rotor sealing face 203 but have feeding holes and deep feeding groove on the stator sealing face 202. This is quite natural if the rotor is made of hard material. The deep feeding groove can be round 131 or rectangular 132 at the bottom. Alternatively, we can put feeding hole 105 and deep feeding groove 104 on rotor face 201, but leave sumping grooves 101,106 on stator as shown below. The

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PerkinElmer, Inc. 45 William Street

Wellesley, MA 02181-4078

Title: Retractable adaptive divert-groove film-riding face seal

Inventor(s): Xiaoqing Zheng

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feeding holes 105 are aligned in an angle with the rotating axis against the rotational direction in this way, the rotation effect makes the feeding more effective. The configuration is shown in Figure 3. But for high-speed rotor, the feeding hole 105 may create serious stress concentration. Therefore the first arrangement is preferred.

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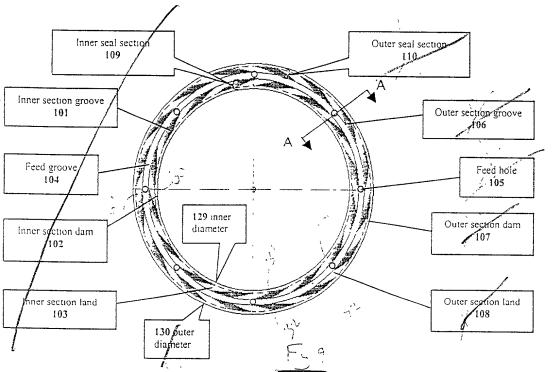


Figure 2. Non-Segmented Divert Groove Face Seal

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	Stator/rotor face		Rotor/stator face
8	B - 3/0		
	or		ing hole 105
Feeding growe 13/1	B(rotor case) Figure 3: Divert double-g		k groove 132
For the convenience of demo put on the stator ring 100.	nstration, in all the figures show	vn hereafter, we assur	me all the features are
supported by a bump 123 on provide additional closing for spring 122 holds the stator ba	w of the stator. The stator ring the back. The bump is also cal se and serves as a support poin ack if the pressure difference ac	led back seat 123. Its, it for the stator ring 10 cross the seal is small.	main function is to 0 to rock on. Retracting 1. This feature is used to
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Docket No Seal137US

PerkinElmer, Inc. 45 William Street

Wellesley, MA 02181-4078

Title: Retractable adaptive divert-groove film-riding face seal

Inventor(s): Xiaoqing Zheng

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Key elements of the invention:

A unique feature of the new face seal is that it pumps fluid from inside to edges. This allows the seal to work at tough conditions of severe face deflection. Since the fluid enters from the center, face coning will never cut off fluid from getting into the seal face. The groove profiles are designed to have desirable pumping effects and film stiffness. Even though we still call it doubte-spiral groove seal, the groove shape does not necessarily have to be a spiral. As a matter of fact, the spiral curves are usually approximated by circular arcs for the ease of manufacture. Furthermore, this invention suggests use of groove profile curving forward 119 instead of conventional curving backward in cases that stronger pumping effects are needed. The alternative groove profiles are shown below.

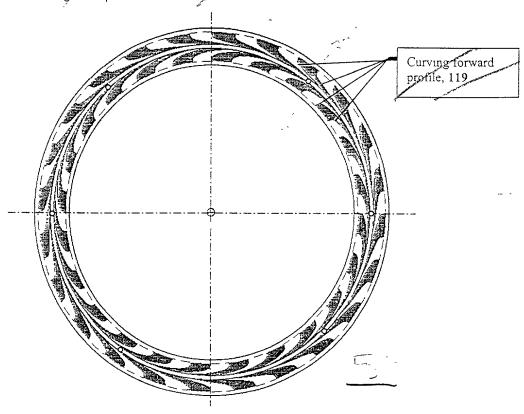
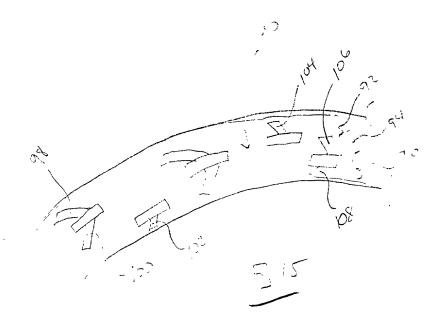


Figure 5.- An-alternative groove profile

In order to make the stator ring 100 adaptive to rotor face 201, the stator ring is designed to be flexible in terms of coning deflection. Therefore the thickness of the stator ring is chosen to be as small as the manufacturing process can allow maintaining flatness of the seal face. The flexibility of the stator ring combined with the restoration capability of the seal face makes the seal highly adaptive to the rotor ring face 201. The mechanism is explained in the following.

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/ellesley, MA 02181-4078 tle: Retractable adaptive diver	t-groove film-r	iding face sea	al	<i>(</i>	9 oF
ventor(s): Xiaoqing Zheng					•
efore we go on to discuss the	stator respons	ses to rotor de	effection let us o	define the sign of	coning
effection first. Following the fac ameter 129 to inner di <u>ameter</u>	ce seal conver	ntion, if the co	ning causes a cases a cases a case	livergent gap 128 e coning by either	from outer stator or ro
duses a convergent seal gap 1 fined as positive.	28 between th	ne stator and	rotor sealing fac	ces 200,201 , the c	coning is
gure 6 shows a typical pressu					
of the sealing face 201 and the some the outer seal section, feed	ding groove ar	nd inner section	on and their equ		
ustrated with vectors. The state	or ring experie	ences a neum S	oment of Zero.		
Stator face			· 0 · 1	Stator ring	
200	~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~		256		
Total outer section force			~~~	Stator hold	er ~
151	88				
Pressure				Stator face	
profile, 150			X X	<u> </u>	
Flow directions	-		7.	Feeding ho	le
Feeding section force	V			105	
151	6 B		Back's	eat	
Total umer section force			7/2		
151				Secondary	E al
Fun gap	73			124	
	i		2		
_Figure_6De	si gn condition	without rotor-	deflection	3/2	_
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Elmer Aud scences	INVENTION DISCLOSURE		ket No. 1370S
PerkinElmer, Inc. 45 William Street Wellesley, MA 02181-4078 Title: Retractable adaptive div	rent-groove film-riding face seal	Page	8 of 11 10 oF/2
Inventor(s): Xiaoqing Zheng			·

When the rotor face 201 deflections cause negative coning, the outer seal section 110 is working in a convergent film (refer to the flow direction 131). That makes the groove 106 work more effectively to create higher pressure in the hydrodynamic section. Therefore, the outer seal section 130 generates more positive moment to open up the clearance at outer diameter 130. Meanwhile, the inner seal section 109 is working at a divergent film. That reduces the hydrodynamic effects of the grooves 101. Less pressure, and therefore less negative moment, is generated by the inner seal section 109. The net increase of positive moment causes the stator ring 100 to cone positively and form a uniform film thickness as shown in Figure 7.

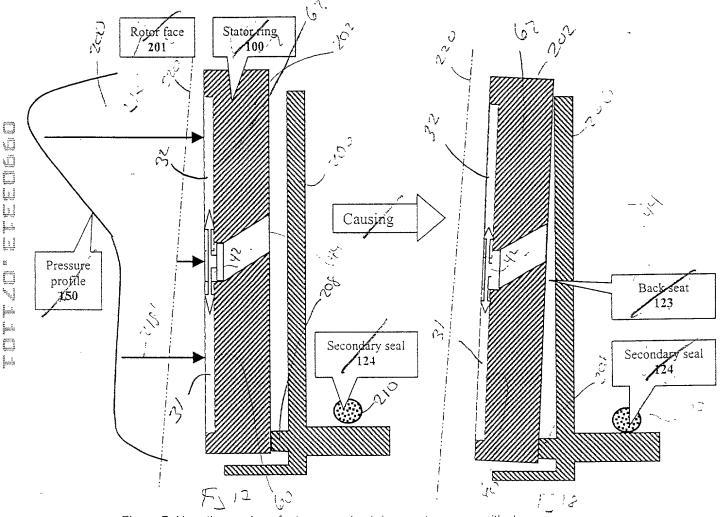


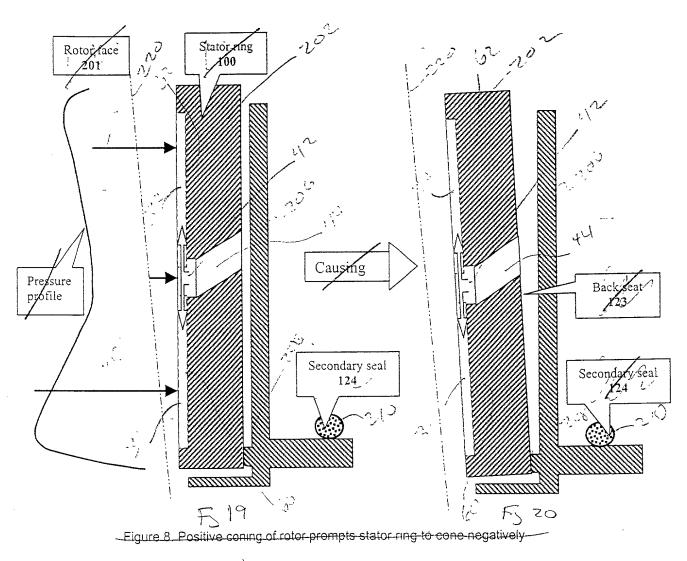
Figure-7. Negative coning of rotor prompts stator ring to cone positively

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Inventor(s): Xiaoqing Zheng

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PerkinElmer, Inc. 45 William Street		Page 9 of 11
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When the rotor face 201 deflections cause positive coning effect, the outer seal section 110 is working in a divergent film. That makes the groove 106 work less effectively to create high-pressure zone in the hydrodynamic section. Therefore, the outer seal section 110 generates less positive moment. Meanwhile, the inner seal section 109 is working at a convergent film. That increases the hydrodynamic effects of the grooves 101. Larger pressure, and therefore larger negative moment, is generated by the inner seal section 109 to open up the clearance at inner diameter 129. The net increase of negative moment causes the stator ring 100 to cone negatively and form a uniform film thickness as shown in Figure 8.



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prevent seal faces from touchi shown below. Please note tha corresponds to wherever the s	t the top does not nece:	engine start-up and shut- ssarily correspond to out ,	down. A typical stator is er diameter 180, it rather
	•	G_{\prime}	\mathcal{X}
\wedge	AA	, N	/
			17/17
Stator ring, 100	/	+	<i>\$</i>
No.	Engine stationary part		1
Rôtor ring face,	Engine stationary part		
201/	System	\$	
Outer dam	pressure side V		Retracting spring, 122
107	~ P / The		
Outer grøove,			
106			
		114 H H	
Feeding hale,	1	177777	Back seat.
	1	VIIIIA	
Feetling groove, 104		> (////	77777
		/////////////////////////////////////	
Inner groove,		1	× × × ×
101	, X / / /	+	
	Discharge 53.		
Inner dam.	pressure Backse	al, Stator holder, 121	Secondary seal 124
•	CIA		
	, V.	section V	
	Figure 4. Seal cross	section 21	
e e			
,	-		
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